CLAIMS

1. A multi-layer piezoelectric element comprising a stack formed by stacking piezoelectric layers and internal electrodes alternately one on another and external electrodes formed on a first side face and on a second side face of the stack, one of the adjacent internal electrodes being connected to the external electrode formed on the first side face and the other internal electrode being connected to the external electrode formed on the second side face,

wherein the metal composition contained in the internal electrodes contains group VIII metal and group Ib metal of the periodic table as the main components, and contents of the group VIII metal and the group Ib metal are set so that proportion M1 (% by weight) of the group VIII metal and proportion M2 (% by weight) of the group Ib metal satisfy the relations $0 < M1 \leq 15$, $85 \leq M2 < 100$ and $M1 + M2 = 100$.

2. The multi-layer piezoelectric element according to claim 1;

wherein the group VIII metal is at least one kind selected from a group consisting of Ni, Pt, Pd, Rh, Ir, Ru and Os, and the Ib metal is at least one kind selected from a group consisting of Cu, Ag and Au.

3. The multi-layer piezoelectric element according to claim 2;

wherein the group VIII metal is at least one kind

selected from a group consisting of Pt and Pd, and the Ib metal is at least one kind selected from a group consisting of Ag and Au.

4. The multi-layer piezoelectric element according to claim 2;

wherein the group Ib metal is Cu.

5. A multi-layer piezoelectric element comprising a stack formed by stacking piezoelectric layers and internal electrodes alternately one on another and external electrodes formed on a first side face and on a second side face of the stack, one of the adjacent internal electrodes being connected to the external electrode formed on the first side face and the other internal electrode being connected to the external electrode formed on the second side face,

wherein a resistance of the internal electrode is higher than a resistance ρAg of the device having the internal electrode of which metallic component consists solely of silver, and is lower than the resistance ρPd of the device having the internal electrode of which metallic component consists solely of palladium.

6. The multi-layer piezoelectric element as in one of claims 1-5;

wherein a resistance of the internal electrode is lower than a conductivity σAg of the device having the internal electrode of which metallic component consists solely of

silver, and is higher than a conductivity σPd of the device having the internal electrode of which metallic component consists solely of palladium.

7. The multi-layer piezoelectric element as in one of claims 1-6;

wherein 80% by volume or more of crystal grains formed from the metallic component that constitutes the internal electrode have particle size of 1μm or larger.

8. The multi-layer piezoelectric element as in one of claims 1-7;

wherein an inorganic component is contained along with the metallic component in the internal electrode.

9. The multi-layer piezoelectric element according to claim 8;

wherein the inorganic component contains perovskite type oxide consisting of $PbZrO_3$- $PbTiO_3$ as the main component.

10. The multi-layer piezoelectric element as in one of claims 1-9;

wherein the piezoelectric material contains perovskite type oxide as the main component.

11. The multi-layer piezoelectric element according to claim 10;

wherein the piezoelectric material contains perovskite type oxide consisting of $PbZrO_3$- $PbTiO_3$ as the main component.

12. The multi-layer piezoelectric element as in one of

claims 1-11;

wherein the temperature of firing the stack is in a range from 900 to 1000°C.

13. The multi-layer piezoelectric element as in one of claims 1-12;

wherein the deviation in the composition of the internal electrode that is caused by the firing operation is 5% or less.

14. The multi-layer piezoelectric element according to claims 3 or 5;

wherein the external electrode is formed from an electrically conductive material consisting mainly of silver and glass, and

wherein proportions of silver contained in the internal electrode and the external electrode are set so that the proportion X (% by weight) of silver contained in the electrically conductive material as a whole and the proportion Y (% by weight) of silver to the total weight of the electrically conductive material and glass contained in the external electrode satisfy conditions of $X \geq 85$ and $0.9 \leq X/Y \leq 1.1$.

15. The multi-layer piezoelectric element according to claim 14;

wherein the internal electrode contains piezoelectric material, and

wherein the proportion Z (% by weight) of silver to the total weight of the internal electrode containing the piezoelectric material satisfies condition of $0.7 \leq Z/Y \leq 1.0$.

16. The multi-layer piezoelectric element according to claims 14 or 15;

wherein the external electrode is formed from a porous electrically conductive material that has 3-dimensional mesh structure.

17. The multi-layer piezoelectric element as in one of claims 14-16;

wherein void ratio of the external electrode is in a range from 30 to 70% by volume.

18. The multi-layer piezoelectric element as in one of claims 14-17;

wherein the softening point (°C) of the glass used in the external electrode is not higher than 4/5 of the melting point (°C) of the electrically conductive material that constitutes the internal electrode.

19. The multi-layer piezoelectric element according to claims 18;

wherein the glass that constitutes the external electrode is amorphous.

20. The multi-layer piezoelectric element as in one of claims 14-19;

wherein a thickness of the external electrode is

smaller than a thickness of the piezoelectric layer that constitutes the stack.

21. The multi-layer piezoelectric element as in one of claims 1-20; the internal electrodes being made of an electrically conductive material that contains silver as the main component and at least one of palladium and platinum, the external electrodes being made of a conductive material including silver as a main component and glass,

wherein the proportion of silver contained in electrically conductive material of the internal electrode near the junction with the external electrode is higher than the proportion of silver contained in electrically conductive material of the internal electrode located inside of the stack.

22. The multi-layer piezoelectric element according to claim 21;

wherein the proportion of silver contained in electrically conductive material of the internal electrode becomes higher toward the external electrode.

23. The multi-layer piezoelectric element according to claims 21 or 22;

wherein the proportion of silver contained in the electrically conductive material of the internal electrode is 85% by weight or higher.

24. The multi-layer piezoelectric element as in one of

claims 21-23;

wherein the glass component contained in the external electrode exists in a region substantially not more than 80% in thickness of the external electrode on the side of the surface of the stack.

25. The multi-layer piezoelectric element as in one of claims 21-24;

wherein the glass component contained in the external electrode contains lead oxide or bismuth oxide.

26. The multi-layer piezoelectric element as in one of claims 1-25;

wherein the electrically conductive material of the internal electrode diffuses into the external electrode so as to form a neck in the joint between the internal electrode and the external electrode.

27. The multi-layer piezoelectric element as in one of claims 1-26;

wherein a glass-rich layer is formed on the surface of the external electrode on the side thereof facing the piezoelectric layer.

28. The multi-layer piezoelectric element as in one of claims 1-27;

wherein the internal electrode contains voids and the voids occupy 5 to 70% of cross sectional area of the internal electrode.

29. The multi-layer piezoelectric element as in one of claims 1-28;

wherein a groove is formed between the end of the other internal electrode and the external electrode on the first side face, with the groove being filled with an insulating material and a groove is formed between the end of the one internal electrode and the external electrode on the second side face, with the groove being filled with an insulating material, the insulating material having Young's modulus lower than that of the piezoelectric material.

30. The multi-layer piezoelectric element as in one of claims 1-29; further comprising an electrically conductive assisting member formed from an electrically conductive adhesive, containing a metal mesh or a mesh-like metal sheet embedded therein, on the external surface of the external electrode.

31. The multi-layer piezoelectric element according to claim 30;

wherein the electrically conductive adhesive is polyimide resin having electrically conductive particles dispersed therein.

32. The multi-layer piezoelectric element according to claim 31;

wherein the electrically conductive particles are silver particles.